Mach's Principle of Inertia Supported by Recent Astronomical Evidence

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ABSTRACT

Inertial mass is detected on Earth only when matter is *accelerated* or *decelerated.* Recently evidence has been reported for a low-level velocity oscillation with a period of 39 $\pm$ 1 Mpc (127 $\pm$3 Myr) superimposed on the Hubble flow. Like the Hubble flow, this oscillation is assumed to be an expansion and contraction of space itself. If space is oscillating as it expands and the Hubble flow contains a superimposed velocity ripple, matter on Earth will experience alternating accelerations and decelerations relative to the rest of the matter in the Universe. The acceleration curve can be obtained from the velocity oscillation curve simply by taking the magnitude of the derivative of the velocity curve and the acceleration curve is found here to have a period of 63.5$\pm$1.5 Myr. Evidence has also been claimed recently for an ubiquitous $\sim$62$\pm$3 Myr periodic fluctuation superimposed on general trends in the fossil biodiversity on Earth. The periods of the acceleration curve oscillation and fossil biodiversity fluctuations are thus identical within the errors. A second, weaker fluctuation is also detected in both the Hubble flow and fossil biodiversity trends. They too have identical periods of $\sim$ 140 Myr. From this excellent agreement it is concluded here that it is the oscillation in the Hubble flow, through an inertia-like phenomenon involving all the matter in the Universe, that has produced the fluctuations in the fossil biodiversity on Earth, and this may represent the first instance where observational evidence supporting Mach's Principle of Inertia has been found.

Subject headings: galaxies: active — galaxies: distances and redshifts

1. Introduction

Ernst Mach argued that inertia can only be explained if all the masses in the universe are somehow connected, and the means by which such action-at-a-distance can occur has a long history in physics (Sciama 1953; Hoyle and Narlikar 1995). Phipps (1999) claims that Philipp Frank, a Hitler-refugee philosopher of science and physicist who succeeded Einstein in his academic appointment at Prague, attributed to Mach himself the following wording to describe his Principle: "When the subway train jerks, it's the fixed stars that throw you down." Phipps further points out that if the fixed stars are doing what Mach claims, they are doing it right now via action-at-a-distance. They are not waiting millennia for signals of any kind to propagate. However, from studying electromagnetic and gravitational field propagation we conclude that neither of these proceeds instantaneously. Although the Weak Equivalence Principle finds gravitational mass similar to inertial mass, neither is well understood. However, perhaps the most important thing to note is that Inertial Mass is tied to *accelerated* motion while the former is not. A possible explanation for instantaneous action-at-a-distance that relates to advanced and retarded potentials has been discussed by Narlikar (1999).

To date, there have been no observations found that would suggest that there might be a direct link between two physical phenomena through Mach's Principle of inertia. This may not be surprising since, in Mach's Principle, at least one of the two variables must be all of the rest of the

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matter in the Universe. Recently, evidence was reported for a low-level oscillation with a period of 39 ± 1 Mpc superimposed on top of the Hubble flow (Bell 2013) when intrinsic redshift components were identified and removed from the redshifts of the SNeIa sources studied by Freedman et al. (2001). This result is the culmination of many years of work on intrinsic redshifts in quasars and galaxies by us (Bell 2002a,b,c,d; Bell and Comeau 2003; Bell et al. 2004; Bell 2007), and by Tifft (1996, 1997), whose work on galaxies found similar intrinsic components. When the intrinsic components have been identified they can be removed. If the source distances are accurate, when the Vcmb velocities of the sources are plotted versus distance any superimposed oscillation then becomes visible if it is larger than the source peculiar velocities. This can be seen here in Fig 1 and in Figs 3 and 4 of Bell (2013) and Bell and Comeau (2014) where the oscillation can be seen to be visible over 6 consecutive cycles.

In the Big Bang model the cosmological component of the redshift of a source is due to the expansion of space and not to the motion of the object through space. Because of this the cosmological component of the redshift increases by Ho km s^{-1} Mpc^{-1}, where Ho is the Hubble constant. This produces the Hubble slope. If the velocity oscillation we have observed is truly an oscillation in the Hubble flow, as proposed here, for a constant amplitude ripple its observed amplitude also must increase with distance. In Fig 1 here, which has been reproduced from Fig 4 of Bell and Comeau (2014), it is clear that the amplitude of the oscillation does increase with distance. As can be seen from Fig 1, the Hubble constant of the ripple is Hr = 540/270 = 2 km s^{-1} Mpc^{-1}. Although this increase is expected to continue to much larger distances it may not be possible to identify the intrinsic components at large distances because of increasing uncertainties in the cosmological parameters. If the intrinsic components cannot be identified and removed, the ripple cannot be detected. Now, for the first time, the oscillations in the Hubble flow would appear to be something that represents all the matter in the Universe, as is required to check Mach's Principle. However, to check Mach's Principle we also require some matter on Earth that might be affected by these oscillations.

Recently an ubiquitous $\sim$ 62 Myr periodic fluc-

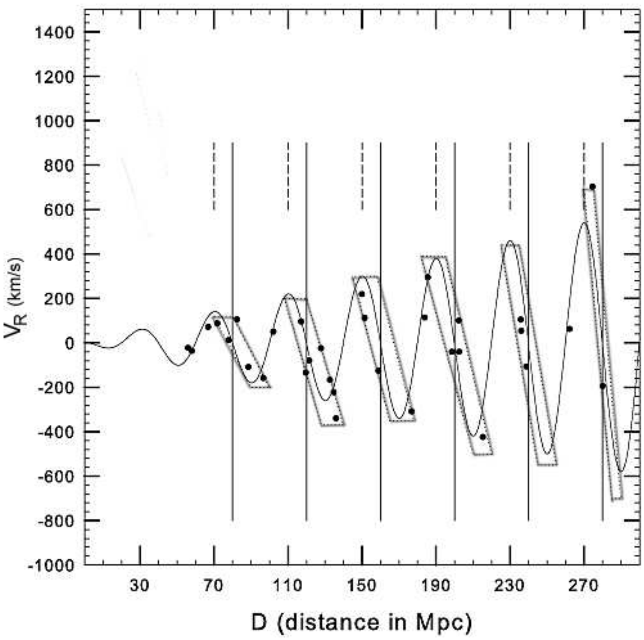

Fig. 1.— Plot of residual velocity, V_R, versus distance for SNeIa galaxies after removal of intrinsic redshifts and Hubble slope of 57.9 km s^{-1} Mpc^{-1} (Bell 2013; Bell and Comeau 2014). Regions of high source density are indicated by the dotted rectangles and are centered near 80, 120, 160, 200, 240 and 260 Mpc, as indicated by the solid vertical lines, and are in phase quadrature with the velocity peaks indicated by the dashed vertical lines.

tuation superimposed on general trends in fossil biodiversity has been reported (Rohde and Muller 2005; Melott and Bambach 2010, 2011a,b). Since the age of the Earth is generally accepted to be 4.5 Gyr, detecting fluctuations in the fossil records with a 62 Myr period should not be hindered by the lack of an adequate baseline. Possible associations between this 62 Myr periodicity and the variation of the Sun around the galaxy have been claimed, invoking the modulation of cosmic rays, gamma rays, and comet impact frequency. A major problem with these models is obtaining accurate observational data from them that can be used to compare with the fossil biodiversity fluctuations. An excellent review of what has been done in this area is given by Feng and Bailer-Jones (2013), who remain unconvinced that the fossil biodiversity fluctuations are likely to be related to these, or other similar Galaxy-related explanations.

In case it is possible that all the matter in the Universe is somehow interconnected, as has been suggested in the inertia phenomenon, one can speculate that the fluctuations in the velocity of the Hubble flow with time might then influence life on Earth in real time, and it is therefore of interest to examine these results more closely. This is especially true in the case of the velocity oscillation where matter on Earth will be alternatively accelerated and decelerated relative to all the rest of the matter in the Universe during each velocity cycle. We now examine if the velocity oscillation we have observed to be superimposed on the Hubble flow might be the true source of the $\sim$ 62 Myr periodic fluctuation superimposed on general trends in fossil biodiversity.

2. Analysis

First we note that the period of the velocity oscillation found to be superimposed on the Hubble flow was 127 Myr, while the fluctuations in the trends in fossil biodiversity on Earth have a period of 62 Myr, which differs by approximately a factor of two. However, since inertia is related to acceleration and deceleration, or the rate of change of velocity, of matter, it is more likely, if inertia is involved, that it is the rate of change of velocity of the Hubble flow oscillation (its derivative), that has affected the survival rate of Earth-based genera. Furthermore, it is unlikely that the direction of the change (acceleration or deceleration) would affect things differently and it is therefore more likely that the effects would be related to the magnitude of this parameter.

One cycle of the fluctuations seen in the velocity of the Hubble flow with a period of 127 Myr (39 Mpc) is represented in Fig 2 by the solid curve. The dashed curve shows the magnitude of the derivative of this curve, which represents the magnitude of the rate of change of the velocity. The curve in Fig 3 is the Fourier Transform of the dashed curve in Fig 2 and shows clearly that the dominant frequency present in the dashed curve is 63.5 Myr (0.0157 cycles per Myr). This is essentially identical to the ubiquitous 62$\pm$3 Myr periodic fluctuation found to be superimposed on the general trends in fossil biodiversity and, in turn, confirms, as speculated above, that the two are likely to be related. Thus, for the first time, the Hubble oscillation model provides us with observational data involving all the matter in the Universe and a baseline that can be compared directly with that covered in the fossil biodiversity case. When the magnitude of the derivative of the Hubble oscillation is used, which is necessary if inertia is involved, the periods found for the oscillations in the two cases can be seen to be identical within the uncertainties.

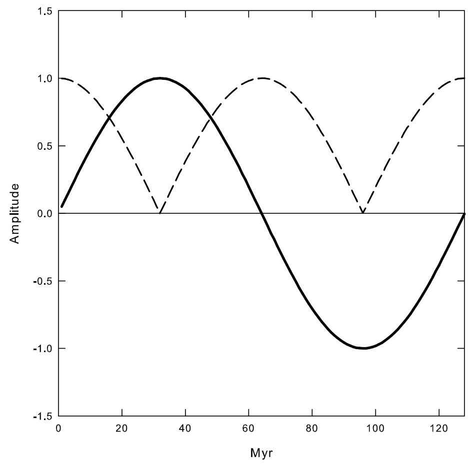

Fig. 2.— One cycle of the fluctuations seen in the density of the Universe and in the Hubble flow with a period of 127 Myr (39 Mpc) is represented here by the solid curve. The dashed curve shows the magnitude of the derivative of this curve, which then represents the magnitude of the rate of change of the velocity of all the mass in the Universe relative to the matter on Earth.

3. Weaker Fluctuations

Rohde and Muller (2005)(see their Fig 1e) re-

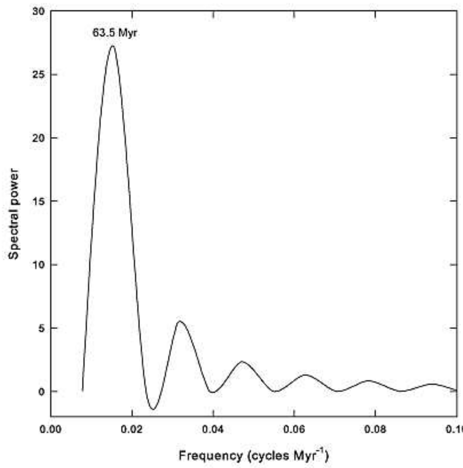

Fig. 3.— Fourier Transform of the dashed curve in Fig 2 showing clearly that the strongest frequency present in the dashed curve is 0.0157 cycles per Myr, which corresponds to a period of 63.5 Myr. This is essentially identical to the ubiquitous 62 ± 3 Myr periodic fluctuation found to be superimposed on the general trends in fossil biodiversity.

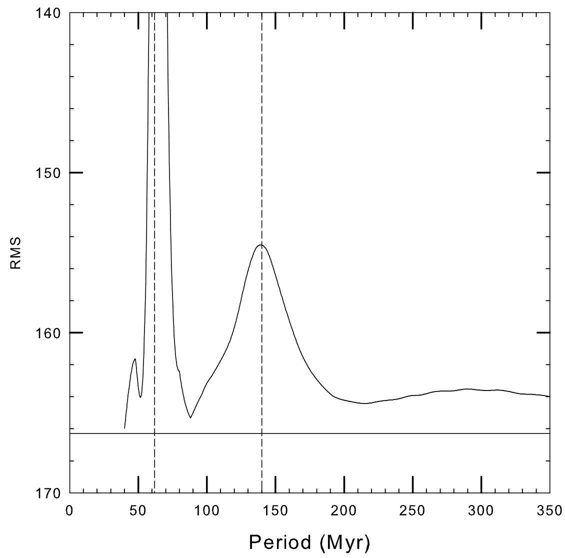

Fig. 4.— The solid curve represents the ripple peaks found previously for the SNeIa galaxies expressed in millions of years, assuming it is the magnitude of the derivative of the Hubble flow that is the driving force. See text for an explanation of how this curve was obtained. Vertical dashed lines show the periods of 62 and 140 Myr that have already been reported in fossil biodiversity trends.

ported that a second fluctuation with a period near 140 ± 15 Myrs might also be present in the fossil biodiversity trends. It was also reported previously by us (Bell 2013) that a weaker fluctuation in the Hubble flow might also be present with a period near 87 Mpc, or 283 Myrs. Again, if it is the magnitude of the derivative of this fluctuation that is affecting the trends in fossil biodiversity we would expect it to appear there with a period of one-half this, or 141 Myr. These results are shown in Fig 4 where the curve has been obtained by subtracting best-fit sinusoids from the SNeIa data, recalculating the RMS value, as described previously (Bell 2013), and converting the fluctuation period from Mpc to Myr using the relation Py(Myr) = [3.26/2]Pp(Mpc). Here the factor 3.26 converts from Mpc to Myr and the factor 2 takes into account the fact that it is the magnitude of the derivative of the fluctuation that is important. In Fig 4 there is excellent agreement between the two periods found in the biodiversity trends (62 and 140 Myrs shown by the vertical dashed lines) and the periods (63.5 and 141 Myrs) found in the Hubble flow assuming that it is the magnitude of the derivative of the oscillation that is the driving force. In both cases (biodiversity and Hubble flow) the short period fluctuations are stronger than the long period ones. This excellent agreement in both period and relative amplitude suggests strongly that it is the oscillation in the Hubble flow that is the source of the fluctuations detected in the fossil biodiversity. The excellent agreement, in both period and relative amplitude, makes it very unlikely that this has occurred by chance.

4. Instantaneous Communication

Previously, we (Bell 2013; Bell and Comeau 2014) used the source distance (look-back time) to show from changes in the density and velocity fields that the Hubble flow was oscillating as it was expanding. This assumed only that the radiation used to detect the sources was propagating at the speed of light. From the results obtained here, if the periodicity seen in the fossil biodiversity is related to changes in the density or velocity fields in the Universe through some kind of inertia-like phenomenon, the effects of these changes would have to be communicated instantaneously. If a communications travel time were involved, such as the speed of light, the time-related effects from matter located at different distances would introduce a smearing effect that would prevent any significant periodic effect on matter located on Earth from being detected. This observation then has the same instantaneous communication requirement as Mach's Principle with the changes in the density and velocity being instantaneously felt by all life types (genera) on Earth.

If this action-at-a-distance is related to the quantum entanglement phenomenon, which requires that all the matter in the Universe at one time had to be connected, we might argue that this picture then agrees well with the Big Bang model. For further discussion see Buniy and Hsu (2012).

5. Conclusions

It is shown here that the two dominant periods present in the fluctuations reported in the trends in fossil biodiversity of Earth-based genera (62 ± 3 and 140 ± 15 Myr) are essentially identical to the periods of the derivatives of the two strongest oscillations seen to be superimposed on the velocity of the Hubble flow (63.5 and 141 Myr). We conclude that it is the oscillation in the Hubble flow that has produced the fossil biodiversity fluctuations. For these effects to be somehow related requires that there be an instantaneous, or action-at-a-distance, relation between the matter on Earth and all the rest of the matter in the Universe, as is the case for Mach's Principle. Finally, it is concluded that the results obtained here might be the first empirical evidence supporting Mach's Principle of inertia.

6. Acknowledgements

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REFERENCES

Bell, M.B. 2002a, ApJ, 566, 705, DOI 10.1086/338272

Bell, M.B. 2002b, ApJ, 567, 801, DOI 10.1086/338754

Bell, M.B. 2002c, arXiv:0208320

Bell, M.B. 2002d, arXiv:0211091

Bell, M.B. and Comeau, S.P. 2003, arXiv:0305060

Bell, M.B., Comeau, S.P. and Russell, D.G. 2004, arXiv:0407591

Bell, M.B. 2007, ApJ, 667, L129

Bell, M.B. 2013, ApSS, 344, 471, DOI 10.1007/s10509-012-1344-7

Bell, M.B. and Comeau, S.P. 2014, ApSS, 349, 437, DOI 10.1007/s10509-013-1601-4 (arXiv:1308.2624)

Buniy, R.V. and Hsu, S.D.H. 2012, Physics Letters B, 718, 233

Feng, F. and Bailer-Jones, C.A.L. 2013, ApJ, 768, 152,

Freedman, W.L., Madore, B.F., Gibson, B.K., Ferrarese, L, Kelson, D.D., Sakai, S., Mould, J.R., Kennicutt, R.C., Ford, H.C., Graham, J.A, Huchra, J.P., Hughes, S.M.G., Illingworth, G.D., Macri, L.M., and Stetson, P.B. 2001, ApJ, 553, 47

Hoyle, F., and Narlikar,J.V. 1995, Rev. Mod. Phys., 67, 113

Melott, A.L. and Bambach, R.K. 2010, arXiv:1011.4496

Melott, A.L. and Bambach, R.K. 2011a, Paleobiology 37, 92-112

Melott, A.L. and Bambach, R.K. 2011b, Paleobiology 37, 383-408

Narlikar, J.V. 1999 in the book entitled "Action at a distance in modern physics: Pro and Contra" editors Andrew E. Chubykalo, Viv Pope and Roman Smirnov-Rueda, published by Nova Science

Phipps, T.E. 1999 in the book entitled "Action at a distance in modern physics: Pro and Contra" editors Andrew E. Chubykalo, Viv Pope and Roman Smirnov-Rueda, published by Nova Science

Rohde, R.A. and Muller, R.A. 2005, Nature, 434, p208, 10 March

Sciama, D.W. 1953, MNRAS, 113, 34

Tifft, W.G. 1996, ApJ, 468, 491

Tifft, W.G. 1997, ApJ, 485, 465

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